REPORT

OF

ELECTRIC LIGHT COMMITTEE

TO THE

TOWN OF MERRIMAC

AMESBURY:
Amesbury Daily News Print
1915

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ELECTRIC LIGHT COMMITTEE

TO THE

TOWN OF MERRIMAC

TOGETHER WITH

PRELIMINARY AND FINAL REPORTS

OF

MESSRS RICHARDSON & HALE
CONSULTING ENGINEERS

AMESBURY:
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Preliminary Report by Richardson & Hale to Electric Light Committee

May 12, 1914

ESTIMATE OF COST FOR ADDITIONAL HOURS OF STATION OPERATION.

You wish an estimate of the additional cost to the town, if your plant is run during the hours when it is now idle. Since meeting your committee Wednesday night, we have had but little time to work on this estimate, but furnish herewith approximate figures with the understanding that on further study, they may be revised, although we think the variation from figures here given will not be essential in deciding the matter.

Data we have used is as follows:—

Present Conditions

During week days plant for the year now averages 19½ hours.

During Sundays plant for the year now averages 9 hours.

During three holidays plant does not operate except 9 hours as on Sundays.

During noon the plant is shut down for ¾ hour week days.

Additional Hours.

(a) For 52 Sundays plant will have to operate 15 hours.

(b) For 3 holidays plant will have to operate 9 hours. (Sunday load.) 15 hours. (balance.)

(c) For 310 week days plant will have to operate 4½ hours.

(d) For 310 week days plant will have to operate at noon ¾ hour.

We estimate the hourly rate of output for all except the noon hour, as about 5 kw.: for the noon period as about 12 kw., and the hours of the three holidays will be divided as for Sunday load for 9 hours, 75 kw. hrs. and 15 hours at 5 kw.

This gives us 2220 hours @ 5 kw. (a), (b) 15 hours, (c) 27 hours with 75 kw. hours (b 9 hours), 232.5 hours @ 12 kw. (d)

The kw. hours are then 11100 plus 75 plus 2790 equals 13965 say 14000 kw. hours output.

We have some data to estimate the coal consumption on, and believe about 30 pounds per kw. hour will be approximated on such an extremely light load for the units you have. This means 420,00 pounds of coal or 187.5 long tons which at $4.60 means $862.50. Twenty-four hour operation will mean another engineer at say $900., also increased charges for oil waste, repairs, etc. which we estimate at about $100. This makes a total increase in expense of $1862.50, say $1900.

Against this you will have an income derived from customers' meters, which we would estimate would record about 30 percent for 5 kw. pr. hr. rate and 70 percent for the balance, giving about 5335 kw. hrs. paid for. Assuming a figure of 11 cents for this, the income would be about $600.

This leaves a remaining charge of $1300. to the town.

In the above, the street lights have not been included or considered in any way. The additional evenings run, which would come when there is no moon, will be small and would not alter the approximate results.

STATEMENT REGARDING PURCHASE OF OFF-PEAK CURRENT.

You are also considering the purchase of electricity from Amesbury, for the hours when the plant is not now operated as given in part 1 of this letter. The price

named is 13 cents less 15 per cent to the town, for line loss in the distributing system. While 15 per cent would more than cover the loss in the line, we do not believe that it will anywhere near cover the difference between the station watt-meter readings, and the total of the town customers' meters, so that irrespective of the fact that the large users of current having rates of 11 cents or lower, are the probable large users of current during the night, we believe the town would lose money on this basis.

If the sentiment of the town is for 24-hour lighting service, we advise that a vote be passed authorizing the Electric Light Commissioners to give 24-hour service, but that the question of how it may give such service, be left open to be decided by the committee. Then we advise the committee to have the plant operated for 24 hours, keep records of the output for the additional hours separate from the other records.

When the committee is ready to report finally on the plant, it can report in favor of purchase of electricity under the several conditions: for 24-hour supply, with or without pumping; for off-peak supply; for operation of plant as at present, and purchase for additional hours to give 24-hour service; or it can report in favor of the present plant operation.

As strongly as we can, we advise against the town contracting with any party for the purchase of any electricity at the present time, since with the transmission line once connected with the plant, you will not be free to choose to best advantage, if you wish to report in favor of a different scheme, because you will then be a customer of one plant, and another plant may well consider your territory covered, and so not feel free to quote figures. Further, you could not get this service except for a period of more than a year at least, we should think.

With an outside company once connected to your

plant, you will not be in as good condition to bargain with them for a different service, nor with an outside party for any service.

PUMPING MACHINERY.

The plungers on the water end of the large pump, are in poor shape. We are told that they are of solid pattern, that is there are no rings to take up wear. We are informed that a new plunger has been ordered to replace one that shows the greater clearance.

The steam cylinders are arranged for steam jacketing, but for some reason or other, they are not so used. Repairs should be made so that steam can be used in the jackets, as this results in considerable economy in operation.

The slip of the pump is high. It varies, of course, with the load on it, but under average conditions amounts to about 15 per cent. With proper attention to plungers and valves, this should be reduced materially, say 6 per cent or even less.

The condenser pump is in bad shape and operates badly. The pump on the sand separator also is in bad condition. These pumps operate badly, they constantly stop, and require blows from an iron bar kept for that purpose, to start again. These pumps should be thoroughly overhauled and replaced with new pumps, if found necessary. The test figures have not been sufficiently worked out as yet, to give exact conditions, but they indicate that these two pumps, and the boiler feed pump, consume nearly as much steam as does the large pump, whereas they should not take more than 15 per cent as much.

Best economy of operation can hardly be expected from this plant, as it operates at between one half and one third of its capacity, but there will unquestionably be a material saving, should the plant be put in proper condition.

Piping.

The covering is off the steam piping in places, and we noticed that steam was leaking from same just above the branches into the steam cylinders, of the water works pump.

The piping to and from the feed pump is not braced properly, to decrease the chance of breakage, due to an accidental blow.

The valves throughout the plant are in leaking condition, and all should be gone over and made tight. Apparently the feed valves and checks on boilers are not tight. The piping for water supply to boilers, from the town main, apparently requires the water to go through the feed pump. This should be changed so that water could be fed directly to the boilers (at reduced pressure) in case the feed pump was out of condition.

Boilers.

We could not examine these, since they are in use every day. One, however, is patched we learn. Considerable trouble is caused by scale. We suggest that the water be analyzed, and a proper solvent be determined upon, and then used at regular intervals, a suitable device being installed for its injection into the feed pump discharge line.

Engines and Generators.

The engines are of good type for simple non-condensing ones, but the valve settings could be improved. The small engine has the paint knocked off in many places, showing a poor attempt at first class up-keep. This engine was also pounding at the time the test was run, the pound being apparently in the crank case.

We were told that the two units could not be synchronized, but no one about the station seemed to be able to state why this was so. With two belted units of

same make throughout, they should synchronize, and if they were, the dip in the lights when changing from one to the other, would not occur.

We understand that the large engine has been rebored and valves scraped and adjusted lately, and that the small unit is to be overhauled shortly.

The large engine is run throughout the day, at times when it would seem perfectly feasible to carry the load on the smaller unit. It is stated that the Judkins' elevator throws such a starting load on the plant, that the voltage drops. If a suitable voltage regulator was installed, we believe this would be obviated to a great extent, if not entirely. We believe further that you would be perfectly justified in requiring a change in this elevator connection, to reduce the starting effect.

The small engine is rated at 100 pounds pressure as 130 hp. and its generator at 75 kw. This is at 100 per cent power factor, meaning that it is of 75 K. V. A. size, and its capacity will be reduced with a lower power factor. Assuming that your power factor, during power load times, is about 70 per cent. the power output of the generator would be 52.5 kw. The maximum load you had on the plant during the test, was 58 kw., assuming 70 per cent power factor for the volts-ampere readings, so that this unit should be able to carry the load without trouble. The ampere rating of the generator is 17 per phase, and the highest ampere reading recorded on test is 17½ and 20, and this held for but 2 or 3 minutes, and the generator should certainly carry 25 per cent overload for 2 hours without undue heating. The above figures show about 110 per cent full load for this unit. We are informed that the unit will not carry such a load.

With this load the large unit of 120 K. V. A. generator capacity and 197 hp. engine capacity was about 69 per cent loaded, and of course the economy is poor in consequence. The load mentioned above is the maximum,

and did not last long, so there should be no question, but that the small generator could carry same. The engine without question is large enough, so if the belt slips it may need dressing or tightening. We have had no time to work up the indicator cards taken, so can give no data from them.

Feed Pump.

We criticised the plant on our first visit, in that there was no auxiliary feed device for the boilers. Last Saturday we were informed by your secretary that the fire pump was the boiler feed auxiliary required by law, and were told when we were at the plant, that town water could be fed to the boilers at reduced operating pressure, when the feed pump was out of commission. The fire pump, we are told, will operate at 50 pounds steam pressure, so that the fire pump could maintain water in the piping system, and the boilers fed from town pressure but since the pipe from the town water line is connected to the feed pump only, and not directly to the boiler feed line, it would be impossible to feed the boilers with this pump removed, or with the water cylinders cracked, head broken or similar accident, without pipe being cut in as a by-pass to the pump. The plant, therefore, has not a direct auxiliary feed as it should have.

We know such a condition is very unusual, and consider that it is a disgrace to the plant.

We advise the immediate installation of a duplicate feed pump, piped in such a manner that either pump can be used alone, or both can be used together, with suction from the swamp well, or from the town well supply. Such a pump would cost about $75. and to install same, including piping $50. additional, or a total expense of $125. We also advise the complete overhauling of the present pump.

When you consider that this pump has been in service every hour that the plant has run since 1904, it should be realized that such a piece of apparatus has done faithful service, and when it arrives at the present condition, when the engineer has to keep a bar at hand to pry it by the center, or to knock the valve rod, it is clear that it has been sadly neglected. When the pump broke down on our test, the water cylinder head was removed, and it was found that the piston nut was off, the pin through the rod having been sheared off, due to the fact that the threads for the nut in the rod, were stripped, affording the nut little if any hold on the rod. Your engineer when repacking the pump, shortly before the test, must have seen this condition, although he did not mention same to your sub-committee.

Switchboard.

The switchboard seems to be in good condition, with sufficient instruments and switches for the service. Whether or not the instruments are correct, we do not know, as we have made no tests on same. Some, we know have a positive zero reading, due to permanent set in the spring.

Our data is based on these instruments, and while they may be out somewhat, we should not expect them to be enough, so as to vitiate the results.

Behind the switchboard, there are two voltage regulators for boosting the line voltage on each phase, if due to unbalancing of load, such is necessary. We could find no one at the plant who knew about them, or how they were to be used, and were told they were not used. This piece of apparatus was installed in many cases some years ago, but a representative of the maker stated that he never knew of there being any sold for some years, and he would have to look in old catalogues to find out about them. We suggest that they be disconnected from

the line, unless they are found to be serving some useful purpose.

Summary.

The plant shows that little if any attention has been paid to its up-keep, and only what was necessary to keep the wheels turning, has been done in the way of repairs. The cost of repairs which should have been made, has been paid for many times over by the increased coal consumption, and still the repairs must be made and paid for. We should judge that this condition has been going on for years.

REPORT ON WATER WORKS AND ELECTRIC LIGHT PLANT, MERRIMAC, MASS.

The Electric Light Committee,
Merrimac, Mass.

Gentlemen:—

Attached hereto is our report relative to the conditions at your Electric and Water Works Town Plant.

We have studied all the data available from several points, and have made up our figures in this report, using our best judgment as to their use in the various ways.

The station records taken during parts of March and April did not give us satisfactory results for basing calculations upon, and your sub-committee decided it was advisable to run a plant test.

This committee made the necessary preparations as desired by our representative, in a very satisfactory way, and helped us all through the test as recorders. Due to the fact that the feed pump broke down before we could complete the test on the waterworks pumping apparatus, at the close of the day's run, your sub-committee ran a pump test of May 10th, to give us the data which we desired to get. Where corresponding measurements were made they checked closely.

You have put several questions to us regarding various matters, and three questions are answered under the various sections, together with other matters presented for your consideration.

The sections of the report are headed as follows,

and explain in a general way, their subject matter:

Sect. I—Test Data of May 7th and 10th.

Sect. II—Proportioning Coal Between Departments.

Sect. III—Present Plant. Cost of Operations.

Sect. IV—Additional Yearly Cost for Steam Generated 24 hr. Service.

Sect. V—Advisability of Pumping at Night Rather Than in Morning.

Sect. VI—Oil Engine Pumping Unit.

Sect. VII—Comparison Between Present Costs and Costs of Purchased Energy.

Sect. VIII—Remarks on Distributing System.

Sect. IX—Estimates of Possible Economies.

Sect. X—Data Regarding Purchased Energy.

Sect. XI—Sources for Purchase of Outside Energy.

Sect. XII—Conclusions.

We on May 12 gave you a preliminary statement as to our investigation, following up the previous information given on March 28th. The matter presented in the above two communications was made before satisfactory figures were available, and while certain statements therein remain unchanged the figures quoted should be considered, as they were given, as only preliminary, and the action of the committee or town should be based upon this final report.

We have not given a list of the plant apparatus in this report, since such information is available from the Town Reports, and besides is pretty well known by the Committee.

The last section of the report shows a brief statement of the plant conditions, and our conclusions as to what the Town could save by making certain improvements, operating under more efficient conditions, and by the purchase of energy from an outside source, at a figure of 2 cents, more or less per kw. hr., a price which should be approximated to make a commensurate saving. If we

were authorized by the Town to decide between operating the plant by steam or by electricity at a favorable rate, we should decide in favor of the later, always of course provided a satisfactory contract could be arranged.

We shall be glad to go into further explanations or calculations as the Committee may desire, along the lines of this investigation, or to serve you further in arranging the technical ends of any contracts with supplying companies, or in putting the plant into proper shape for more economical operation.

Respectfully submitted,

Richardson & Hale

September 25, 1914.

SECTION I.

Test Data of May 7th and 10th

At the request of your sub-committee authorized to make tests, as they thought requisite, we ran a test on the boilers, engines, generators, pumps, etc. on May 7th, beginning at the start of operations, and ending at the usual hour of 1 a. m. the next day. As planned there was to be run a test on the waterworks pumping apparatus after 1 a. m. to obtain information not available while the engines were in operation, but for reasons stated this could not be done, although an attempt was made toward this end before the breakdown occurred.

Accompanying this section are Tables I, II, III.

Table I shows the Electrical Data of the Test May 7.

Table II shows the Boiler Data of the Test May 7.

Table III shows the Data of May 7 more extended, as worked out for more detailed results.

A summary of the two pump tests is given later in the report.

The following sub-section concerns the electrical data of the test, and reference is made to Table I. This section also makes recommendations regarding the units to be used.

Electrical Data from Test, with Recommendations Regarding unit to be used.

During the test, readings of the station electrical instruments were made at frequent intervals. It must be clearly understood that the instruments were taken as they stood, no calibration or correction of any kind being attempted, and that if the instruments are in error, the results would be effected. We do not detect evidence of any large errors, and small errors would not show up.

Table I herewith gives a summary of the electric readings together with some calculated values from them, taken during the test. Most readings were taken every 2½ minutes, although only the readings taken on the quarter, half, three quarter and hour periods are indicated. Considering the data in the table we note the following:

Primary voltage ranged from 2210 to 2320, 4 per cent to 5 per cent.

Maximum momentary (large unit) Amps. 17.5 and 20.0

Maximum momentary (small unit) Amps. 10.3 and 10.1.

These values are from all readings, and from notes taken for maximum readings.

The rated ampere capacities are given on the name plates per terminal as follows:—

For large generator 27.3 amps.

For small generator 17.0 amps.

It will thus be seen that at no time recorded, did the ampere requirements of the load for any terminal, reach a momentary value of rated ampere capacity greater

than 73.3 per cent for the large generator when in use, and 60.7 per cent for the small generator when in use.

The instrument index arms did swing to higher readings, but did not stay there.

Had the small unit been operating when the heavier load occurred, momentarily, there would have been an ampere overload of 10 per cent which the unit should have stood. This unit is, according to the Report of Engineers under whom same was installed in 1905, capable of carrying 50 per cent overload for one hour, and 25 per cent overload for 24 hours without excessive temperature rise. The statement was made that the small unit would not carry the day load, the belt slipping on the momentary peaks occurring. A load of 17.5 plus 20.0 equals 37.5a at 2300v equals 86.3 KVA, and with a power factor of 70 per cent this KVA load is equivalent to 86.3 times .7 equals 60.4 kw. The capacity of the machine is 78.2 KVA (100 per cent P. F.) or 54.7 kw. at 70 per cent P. F. which is an overload of 10 per cent. This certainly should cause no trouble as indicated above, if the belt were in proper condition. A voltage regulator should take care of any regulation troubles.

The average amperes from 8:30 a. m. to 12 m. and 12:45 p. m. to 5 p. m. when load was heaviest was (15 min. readings) 14.1 and 17.2 amps., which is practically the full rated generator load for the small unit on one terminal, and 83 per cent on the other terminal, so that there should be no trouble from heating due to continued use. The average load was 72.0 KVA and with highest P. F. shown (71.8) say 72 per cent, this gives a load of 51.8 kw., which should be easily carried by an engine bought for a 75 kw. generator, and at not over 1-3 cut off.

Of course during certain seasons of the year, load conditions might require the operation of the large unit,

but for conditions similar to those at the test, the large unit was unnecessary, and a cause of inefficiency.

We do not believe with the load as on the day of the test (we understand that conditions were then normal) there is any need of operating the large unit at about 62 per cent load, with its consequently decreased economy. If the large elevator in the carriage factory causes such a jump in amperes as to stall the small unit, or drop the voltage decidedly, thus making it necessary to run the large unit, such an elevator should not be allowed on the system, since it is costing the town more than it is getting in return.

We believe, however, that a T. A. voltage regulator (General Electric Co. make) could be advantageously installed in the plant, to take care of all voltage fluctuations, and would make it possible to operate the small unit all day to the satisfaction of everyone, unless a material increase in load occurs.

To bring out the difference in economy by operating the small unit rather than the large one, we give the following:

The maker of the engine gives these economy figures per I. hp. hour.

Pounds of Steam per I. Hp. Hour.

12 ins. x 14 ins. Eng.	80 lbs. Steam	16 ins. x 16 ins. Eng.	80 lbs. Steam	90 lbs. Steam
¼ load	48.7	¼ load	45.5	42.5
½ load	37.5	½ load	35.8	34.4
¾ load	33.6	¾ load	32.6	31.6
1 load	33.1	1 load	32.0	31.0
1¼ load	33.6	1¼ load	32.5	31.5

During the test the large engine ran 11¼ hours (about) at about 90 h. p. or less than ½ load, which

gives an economy of not over 35.8 lbs. according to above figures.

35.8 lbs. times 90 hp. times 11.25 hours equals 36,265 lbs. of steam.

Had the small engine been run during this time, there would have been consumed 33.6 lbs. times 90 hp. times 11.25 hours equals 34,037 lbs. of steam.

The difference is 2228 lbs. of water, and the equivalent coal at 8 lbs. evap. equals 278.5 lbs. coal, say 279, then 279 times 300 (days) equals 83,700 lbs. equal 37.4 long tons.

37.4 @ $5.00 equals $187.

The use of the large engine under the above economy figures, shows a loss of nearly $200 a year, and we believe under the actual operating conditions the above steam economies would not be met. so that the expense would mount even higher.

The power circuit was operated until nearly 10 p. m. turning out 4 to 5 kw. per hour for the time after 5 p. m. We believe that this energy is generated without adequate return, most of it being accounted for by line and transformer losses. There are 126 kw. of transformer capacity alive all this time, with little if any return.

The next column of the table shows that the kw. hours of commercial lighting (there is a small power load on this circuit we understand.) This load ran along through the day at a rate of 8 kws. per hour, in the evening getting up to 17 kw. per hour for a short time. Such an amount is small and should we think, be increased in a town of the size of Merrimac.

We next consider the total load, the table showing that during the working hours of the day this runs at 44 to 55 kws. per hour; between the working day and the street lighting period, the total load drops to 12 to 14 kws. per hour and then rises with the commercial and street lighting loads to 44 kws. per hour, this value decreasing to about 25 kws. per hour as closing down

time is approached.

The following shows the hours, kws. per hour, the rated generator and engine capacity, as they were on the test.

Time	Start to Noon	Noon to 5 p. m	5 p. m. to 7:30 p. m.	7:30 p. m. to 10 p. m.	10 p. m. to stop
Kw. hours per hour (Max.)	53	55	14	44	25
Gen. Cap.	120	120	75	75	75
Eng. Cap.	197	197	130	130	130
Load per cent of Gen. Cap.	42.2	45.8	18.7	58.7	33.3

There should we believe, be installed a 25 to 30 kw. unit which would take care of the small load, such a unit being all the more advisable if 24 hour every-day service is to be given.

The present small engine unit should be run with the day load, if not materially larger than that on day of test, the installation of a voltage regulation being advisable.

The last column shows the power factor (P. F.) calculated from the frequent test readings. This varied from 67 per cent to 71.2 per cent. While the power load is on, and should be improved if possible, although with the motor capacity on, and the fact that they may be underloaded, due to present conditions of operation of the factories, we doubt whether much improvement can be made.

After the principal power load is off, this factor shows an increased value with an increase of lighting load, and decreased value with lower lighting load as expected. With the small lighting load, we doubt whether this could be improved.

The following sub-section shows the data of the boiler test of May 7th, worked out as far as possible, since no analysis was made of flue gases, coal, ashes, wetness of the steam, etc.

Boiler Test of May 7th 1914

Made by Richardson & Hale of Boston, Mass., on boilers in Municipal Plant, Merrimac, Mass., to determine evaporation per pound of fuel, and amount of steam generated under various loads.

Principles governing test were the usual working plant conditions, except for a run of about two hours at end of usual day's run, coal and water for this period, and for breaking out boilers, being omitted except for per cent of ash.

Kind of fuel: Said to be George's creek bituminous.

Kind of furance: Flat shaking grate.

State of weather: Mild, overcast, 66° F.—74° F.

Method of starting and stopping test: Standard, that is with cleaned grates.

1. Date of trial May 7, 1914.
2. Duration of trial 19¾ hours. (5:45 a. m. 5-7 to 1.0 a. m. 5-8.)

Dimension and Proportions of Boilers.

2-6 feet x 15 feet 4 inches H. R. T. Scannell Boiler Works 1905. 140-3 inch tubes 14 feet long ½ inch shells, 9-16 inch heads, 100 lbs. pressure. Brick setting in battery. (Boilers were shortened after being built, because building was too small, we are informed.)

3. Grate surface 6 feet wide 6 feet long 36 sq. ft.
4. Water heating surface 1581 sq. ft. (est.)
5. Ratio W. H. S. over G. S. equals 1581 over 36 equals 43.9.

Average Pressures.

6. Steam pressure by guage 83.21 lbs.
7. Draft in flue on chimney side of damper (damper open) 4-10 inch water.

Average Temperatures.

8. Average temperature of feed water entering boiler 192.9° F.
9. Average temperature of gases from boiler in flue (5 measurements) 544° F.

Fuel.

10. Fuel—size and condition. Good—moist.
11. Weight of coal as fired (for per cent ash use 6691) 6587 lbs.
12. Total ash and refuse 809 lbs.
13. Quality of ash and refuse—contained considerable small particles of unburned coal. Not tested.
14. Total combustible (wet) consumed 5778 lbs.
15. Percentage of ash and refuse in wet coal 12 per cent. No analysis of coal or ashes made.

Water.

16. Total weight of water fed boilers (corrected for level) 56182 lbs.
17. Equivalent water fed to boiler from and at 212 degrees 59294.5 lbs.
18. Factor of evaporation 1.0554.
19. Builders rated horsepower (12 sq. ft. basis) 132 each boiler.

Economic Results.

20. Water apparently evaporated under actual conditions per lb. of coal as fired 8.53 lbs.
21. Equivalent evaporation from and at 212 degrees F per lb. coal as fired (no correction for quality of steam) 9.00 lbs.

Note.

No rates of combustion per sq. ft. of grate, or evaporation per sq. ft. of heating surface can be given, since one boiler was banked during part of the run.

The results show a fairly good evaporation per pound of fuel fired, etc. The temperature of the flue gasses is higher than it well might be, and we believe that with a thicker fire this condition might be improved, and also that the evaporation might also be better.

The figures show what the plant did at the time of the test, but are unsatisfactory for judging the boilers, since there were at times two in use, and at other times but one. We are inclined to believe that results shown are better than have been obtained day in and day out, but such would only be natural under the stimulus of testing.

Table III is later explained in Sect. II.

SECTION II.

Proportioning Coal Between the Departments.

The question of what proportion of the total coal used by the station, should be charged to the Water Works, and what to the Electric Department, involved a determination of the coal used by the different apparatus.

We hoped, by the daily station records which we had kept by the station operator, to determine this without a plant test, but the resulting figures were not satisfactory, so a plant test was run.

Table IV shows the data for the year 1913, the last available, from which the totals used in the report are taken.

Reference is made to tables I and 11 previously explained, and to table III explained below.

The periods of time Col. 1 have been divided as in-

dicated, and all coal, water, etc. shown in table before 7.45 have been disregarded in working out the results for this table, the use of such items being considered as undesirable, because the plant had not settled down to working conditions.

Cols. 3-6 inclusive are simply records from the test log.

The division of coal and water, Cols. 7 and 8 has been made somewhat arbitrarily from notes taken at the time the plant was tested, but in our judgment the figures where varying from those of the original records regarding periods, is justifiable. The principal changes refered to above, are due to unequal conditions of boiler water lines, coal on hand, etc.

The evaporation, column 9, in the morning run was higher than the average, and is good but not equal to the afternoon run. We account for this by the fact that both boilers were in use below full or most efficient load, due to the big pump being in operation. In the afternoon, but one boiler was being worked, and at a better load.

The morning load was about 170 boiler hp., while the afternoon load was about 120 boiler hp., and since the boilers are 130 hp. (12 sq. ft. rating) the latter is a more efficient load. The evaporation fell off as soon as the electric load dropped in requirements. While the figures show a higher evaporation in the last period, than in the previous one, we believe that this is due to the fact that the fires were very low in the boilers, working toward a clear grate at the end of the run, and that had the electric plant been operated the balance of the nightfi that more coal would have been weighed in during this time.

This column shows up the advisability of proportioning the boiler size to the load requirements, and also in operating the units at such times, as to have them fully loaded if possible.

Column 15 similarly shows up the advisability of operating the engines for best load conditions, and these figures of water per kw. hour and those shown elsewhere in the report for the water per indicated hp. hr., while not directly comparable because of the different units used, and other considerations show that low engine loads mean low economy, and that the manufacturers efficiencies will not be met ordinarily in every day practice.

Columns 10-14 inclusive.

The next few columns of the table need no explanation or comment, other than for the division of coal and water during the morning period. For this period the figures not in the brackets are from the figures to the left, except that the coal and water for the big pump and auxiliaries (columns 10, 11, 13) were taken from the pump tests of May 7th and May 10th.

Water Works Apparatus Tests of May 7th and 10th

		May 7th	May 10th
1.	Duration	4 hr. 8 min.	4 hrs.
2.	Total rev.	3379	3349
3.	Aver. rpm.	13.6	13.9
4.	Average dynamic head, May 7th, 71 lbs. equals 163.8 ft.; May 10th, 70.2 lbs. equals 162.1 ft.		
5.	Average suction head, May 7th 19.2 in. equals 21.8 ft.; May 10th, 19.3 in. equals 21.9 ft.		
6.	Total head ft.	185.6	184.0
7.	Condensed water lbs.	4495	4495
8.	Temperature condensed water degrees F	100	101
9.	Average slip per cent.	12.3	11.3
10.	Gals. per rev.	25.75	26.1

11.	Total gals. rev. x g. p. rpm....	87100	89700
12.	Horsepower hrs. pump.......	68.2	69.6
13.	Water fed boilers lbs........	"6682"	8366
14.	Evaporation lbs. water per lb coal	10.55	7.86
15.	Lbs. steam per hp. hr. pump....	65.9	64.6
16.	Lbs. steam per pump hp. hr. auxiliaries	"32.1"	55.4
17.	Coal burned lbs...............	"633"	1064
18.	Lbs. coal per hp. hr. pump....	6.25	8.2
19.	Lbs. coal per pump hp. hr. auxiliaries	"3.04"	7.1

NOTE: Figures in quotation marks taken from derived figures of table 1, since they were not obtained on May 7th test.

This shows a marked difference in consumption for the pump and auxiliaries in the two tests, but this is accounted for in the poorer evaporation during pump test of May 10th, due to the small load on the boilers, namely about 56 boiler hp.

Considering the evaporation amount (May 10) namely 8366 lbs., and reducing this to what it would have been if the evaporation was 10.55 lbs. as on May 7th, we obtain 6230 lbs. which is only 452 lbs. of 6.8 per cent different from the derived amount of May 7th shown between columns ten and eleven of table 1, and which could be accounted for by difference in pump operation.

For this same morning period, the derived figure of 72.0 pounds per kw. hour (column fifteen) is the same as for the afternoon consumption, and we see no reason why this figure should not be used, as the load conditions were practically identical. From this figure and the evaporative rate, is derived 6.82 pounds of coal per kw. hour (column sixteen) for the engines.

Again as a check we have figured the pounds of water per kw. hour for the afternoon runs of April 25, 27,

28, 29, 30, when the feed water meters were in operation, which gives us a mean value of 73.1 pounds of water per kw. hour.

Further figures as given below, show that if the mean kw. hours generated in the morning is multiplied by the mean pounds of water per kw. hour in the morning and again in the afternoon, that the difference is 6100 pounds, which is close to the figure found for the pump, where the May 10th test amount of water evaporated, is reduced to the evaporative basis of the morning period of the May 7th test, this figure being 6230 pounds. While this figure of 6100 pounds seems to indicate that our derived figure of 6682 in table 1 is high, we feel justified in proceeding on the basis of this last named figure, believing that the big pump and auxiliaries take more steam than the lesser figures indicate.

Date	Kw. Hrs.		Lbs. of Water per kw. hr.	
	A. M.	P. M.	A. M.	P. M.
April 25	189	183	112.0	87.4
" 27	190	180	100.0	70.8
" 28	167	175	97.9	73.8
" 29	186	177	117.6	60.7
" 30	172	143	105.0	72.7
Aver.	181	172	106.5	73.1

106.5 x 181 equals 19300 lbs. pump operating.
73.1 x 181 equals 13200 lbs. pump not operating.

6100 lbs. water evaporated required by pump.

The figures in brackets in columns 12, 13, 14, and the figure between colmuns 10 and 11 are derived in the order named from these figures. The figure in column 10 being from both pump tests, and that in column 11 being the difference between the total water derived for

the pump and auxiliaries, and that taken by the pump alone.

The value which is used for proportioning the coal between the Water Works and Electric Departments for the big pump, is the pounds of coal per pump rpm. derived from the above figures, namely 6682 divided by 3379 (no strokes) equals 1.98 pounds of steam per rev.

The total revs. in 1913 for large pump were 1,376,244 which multiplied by 1.98 calls for 2,724,963 pounds of steam.

Since the pump has been run under the conditions of the test, that is at the same time with the morning electrical load, one would expect the evaporation to be the same as on the test, namely 10.55, but the other data available indicates that this evaporation is not ordinarily obtained, but that not better than 8 pounds, is nearer operating conditions. This yould then call for 340,-620 pounds of coal or 152 long tons.

There is no data on the small pump, so that we have to figure the consumption on basis of volume of steam cylinders and rpm. This works out to 0.154 pounds of coal per revolution and calls for 21,334 pounds or 9.53 long tons of coal.

Total coal for the Water Works for the year then is 161.53 tons, and to this we add 10 per cent for station losses, warming up pump, etc. making a total of 178 tons or 402,720 pounds.

The total fuel both departments for 1913 was:

Coal, 2,027,184.

Screenings, 667,884, 2,695,028 pounds.

Of the total pounds the screenings are 24.8 per cent.

24.8 per cent of coal used for Water Works would, therefore, be screenings, the balance being soft coal, and the cost would be:

Coal, 302,845 pounds, 135.2 tons @ $4.93........$667.00

Screenings, 99,875 pounds, 44.6 tons @ $2.82.... 126.00

Total $793.00

The coal prices are not given in the 1912 report, and we have none for 1913, but the committee gave the above prices as being average ones.

The balance of the fuel would be chargeable to the Electric Department or

Coal, 2,027,184 minus 302,845 equals 1,724,339 lbs., 769.8 tons.

Screenings, 667,844 minus 99,875 equals 567,969 lbs., 254.0 tons.

With a cost of coal 769.8 tons @ $4.93 equals..$3795.00

Screenings 254.0 tons @ $2.82 equals...... 716.00

Total $4511.00

Perhaps an easier way would be to determine the pounds of coal per rev. for the large pump, which under the conditions of present operation would be 1.98 over 8 equals .248 pounds of coal (on basis of 8 pounds of water evaporated per pound of coal.)

The method of figuring the division would be as follows:—

Note that where station daily records show column headed "strokes" the wording should be "revolutions."

Large pump revolutions x 0.248 lbs. coal equals..A lbs.
Small pump revolutions x .154 lbs. coal equals....B lbs.

Coal or equivalent equals C
For station losses, etc. add 10 per cent, equals....D lbs.

Total coal or equivalent equals ....E lbs.
Next take total coal for year, equals............F lbs.
Total "screenings" for year equals .... G lbs.

Total ....H lbs.

Coal is 1 per cent of total fuel.

(To get 1 divide F x 100 by H.)

Take 1 per cent of E equals soft coal J lbs.

Balance of E equals screenings K lbs.

Charge to long tons (this is the ton that is purchased) and multiply by the average price. Do not simply average the prices charged, but figure the cost of each lot of coal, add these costs and divide this by the total tons of coal, which will give the weighted average price. Do the same for screenings.

To show why the weighted average should be used. consider the exaggerated case of:

1 ton @	$100 equals	$100.00
5 ton @	2 equals	10.00
	$102	$110.00

Average weighted $110 divided by 6 equals $18.33 per ton.

Average not weighted $102 divided by 2 equals $51.00 per ton.

To answer the question as to what should be charged each department for fuel, we would conclude this section with the statement that for 1913 there should be charged

Water Works $793 or 14.96 say 15 per cent of total of all coal.

Electrical Dept. $4511 say 85 per cent.

For practical purposes we should advise under present operating conditions, that is the pump operating during the morning load (the operation in the afternoon power load period would give similar conditions regarding evaporation) that the coal cost be divided.

Water Works 15 per cent.

Electric Dept. 85 per cent.

We understand you are now dividing it 25 per cent (1-4) and 75 per cent (3-4) respectively.

SECTION III.

Present Plant—Cost of Present Operations.

In this section we make an approximate estimate of the yearly operating cost at the station, for both the departments, giving the total cost and the unit costs, for the Water Works on the basis of one million gallons pumped, and for the Electric Dept. on the basis of kilowatt-hours output, according to the station instruments.

It must be understood that the actual figures of cost will not coincide for any one year with our figures, since they are closely approximate only for a term of years under similar operating conditions. No fixed, office or outside charges are included. The data for these figures are for the output conditions in 1912, and present operating conditions, and due consideration has been given to expenses of other years to avoid extraordinary charges of any kind.

Labor.

The labor item for the year is we are informed:

Two men @ $20 per week, or...........	$2080
Allowing for vacations, sickness, etc.....	120
	$2200 per year

Dividing this on the basis of hours of operation, (Electric Dept. 6004 hours, Water Works 1645 hours 22 per cent and 78 per cent respectively of total hours.) We find the ratio for the Water Works and for the Electric plant to be about 1 to 4 so that we charge:

Water Works Dept. $2200 x 1-5, $440.

Electric Dept. balance or 4-5, $1760.

This division gives the following unit charges:

Water Works per million gals. (36.01) $12.22.

Electric Dept. per kw. hrs. (208,587) 0.843 cts.

Oil and Waste.

This item from the Town Reports for five years averages $185, $45 chargeable to Water Works and $140 to the electric plant. For want of a better basis to divide this unreasonably large charge, we use the division as derived from the Town Reports:

Water Works Dept., $45.

Electric Dept., $140.

Note: The cost of oil for the Electric Department is in excess of any basis for estimate which we know of, so the taking of the town's data seems as fair as any method. How the town authorities arrive at the division we do not know.

These figures give us unit costs as follows:

Water Works per million gallons, $1.25.

Electric Dept. per kw. hours, 0.07 cts.

Fuel.

On basis of 15 per cent chargeable to the Water Works, and 85 per cent to the Electric Dept. we have the fuel costs (see previous section of report.)

Water Works coal and screenings, $793.

Electric Dept., coal and screenings, $4511.

These give us unit costs as follows:

Water Works per million gallons (36.01), $22.02.

Electric Dept. per kw. hr. (208,587) 2.16 cts.

Repairs and Supplies.

This item has been taken from the Annual Town Reports, an average value being used namely for Water Works Dept. $300., for Electric Dept. $400. Why the employees insurance, both public and private, is paid entirely by the Electric Dept. is unknown to us, but same is allowed for in the above amount.

These figures give us unit prices as follows:

Water Works per million gallons (36.01) $8.33.

Electric Dept. per kw. hours (208,587) .19 cts.

Total Stating Costs.

The above figures are tabulated below:

	Water Works		Electric Dept.	
Item	Total	Unit	Total	Unit
Labor	$440	$12.22	$1760	0.843 cts.
Oil and waste ..	45	1.25	140	0.07
Fuel	793	22.02	4511	2.16
Insurance, supplies and repairs	300	8.33	400	0.19
	$1578	$43.82	$6811	3.263 cts.

No rental charge included.

The above shows that the yearly station operating costs, no fixed charges being added, for the departments divided in the most feasible method at hand, are:

Water Works total station operating cost $1578.

Unit cost per million gallons pumped $43.82.

Electric Dept. total station operating cost $6811.

Unit cost per kw. hour generated 3.265 cts.

These costs are high, and we believe can be improved as elsewhere suggested.

SECTION IV.

Additional Yearly Cost for Steam Generated 24-hour Service.

In 1913 your electric plant operated 6004 hours, leaving a balance frcm 24 hour—365 days operation (8760 hours) of 2754 hours when service was lacking. During these additional hours the load would be small under present conditions, even when the street lighting (about 20 kw.) was on.

We understand that the all night burning of street lights is not being considered, and we can see no need for same since the expense would be large compared with the number of people benefited.

The maximum lighting load shown during the test was 17 kw. hours in any one hour, and this fell off to 4 kw. hours towards 1 a. m. Assuming that the load would be somewhat greater than this if it was known that energy was available all night, we do not believe with the present commercial connected lighting load, that this output would exceed 6 kw. per hour, for an average value.

This gives 2754 hours @ 6 kw. equals 16,524 kw. hrs.

Since the plant will be operating a 75 kw. machine for this service, and a 130 h. p. boiler, poor economy would be expected. Judging from the test record, we believe you would not obtain under present plant conditions better than 1 kw. hour on 20 pounds of coal, which gives a total of 330,480 pounds, since the fires are at present banked after the night run, and since the coal for this use is pretty well burned out before morning, it would seem fair to deduct the amount of 200 pounds for 365 days or 73,000 pounds. Deducting this from 330,-480 leaves a balance of 257,480, which at a cost of

$0.0022 per pound amounts to.................	$567.00
The labor charge will be increased by one man..	940.00
Oil, waste, repairs, insurance, etc..............	100.00
	$1607.00

Allow $1600.

Against this you would have an income of not over 50 per cent of the total station kw. hours output at an average rate of say not over 11 cents or 16,524 kw. hours x 1-2 x $0.11, $908.82. Allow $900.

This leaves an increased cost of $700 to the town for 24 hour-every-day commercial lighting service.

If street lighting were done all night and every night, there would be an additional charge for lamp renewals, and probably an additional charge for coal, although the boiler and engine load would be greater, and

the economy, therefore, might be improved enough to offset the increased output.

Our preliminary report on this question gave a larger debit charge of $1300., the figures therein being based on a short 4 hour run, which was the only information at hand at that time, on the fact of no banking coal being credited, and also on a misunderstanding regarding the plant regimen.

SECTION V.

Advisability of Pumping at Night Rather Than in Morning.

You wish us to state whether it would be advisable to pump during the evening load, rather than during the morning load period.

The most economical period of operation during the test of May 7, (see table III) was in the afternoon when the pump was not being operated, this period showing an evaporation of 13.2 pounds of water per pound of coal and 5.45 pounds of coal per kw. hour output. It is noted that but one boiler was at this time in operation, the other one being banked, whereas in the morning both boilers were in use.

During the morning run the above figures were 10.55 pounds water and 6.82 pounds of coal respectively, and both boilers were in operation. In the morning period of 4 1-4 hours 210 kw. hours were put out (rate 49.4) and in afternoon period of 4 1-12 hours 200 kw. hours were put out (rate 48.6) the electrical conditions being practically the same, the onus of operating the second boiler is, therefore, on the pump. Similar efficiency would be expected in the morning, as in the afternoon, as far as the electrical load is concerned.

Conditions between 5 and 7.30 (2 1-2 hours) were very bad regarding efficiency of the electrical plant although the boiler evaporation, one boiler only, was rea-

sonable. From 7.30 to 10 p. m. the load again increased, but not up to conditions with the power load on, the coal consumption improving, but the evaporation decreasing. The electrical load was large enough to obtain better economy from the small engine, than the day load on the large engine, but was not large enough to keep up efficient boiler operation. From 10 p. m. to 1 a. m. the load fell off, the table shows an increase in evaporation efficiency (probably due to temporary conditions as elsewhere pointed out) which we do not think it is justifiable to count upon, and a greater coal consumption per kw. hour as would be expected.

From consideration of these figures we should say that the operation of the water works pump between the hour of 7:30 p. m. and 1 a. m. (5 1-2 hours) would increase the boiler load, causing an improvement of evaporative efficiency. This of course does not mean that you will get more water pumped per pound of steam, but does mean that you will get more steam generated per pound of coal.

If an all night load is to be carried without street lights, the time for pumping would be after the street lamps were put out. If, however, the street lamps are to burn all night, the conditions would be practically as they are after 10 p. m. for the test, namely a load practically of street lights only, so that the advantages to be gained by pump operation would be the same.

The answer to your question is, therefore, that evening pumping would be advisable.

SECTION VI.

Oil Engine Pumping Unit.

Many Water Works plants of recent construction and of sizes about as the one under discussion, have had oil engine pumping units installed, because where a plant is run for such few hours, steam is an expensive

primary source to install, and also to operate. This has caused us to consider the question of oil engine unit in this report, and we have come to conclusion that with your plant installed as at present, it would not seem probable that the town would care to discard it entirely, and to install with an electric driven pump, an oil engine unit with the investment cost entailed, using same as an auxiliary for fire reserve purposes only. The fixed operating charges we believe, would be more than the cost of upkeep, under the conditions required by the Underwriters for the present boilers and auxiliary fire pump.

Since the investment cost for an oil engine unit would be fully $1,000 more, and since the cost of current is but a relatively small item ($750) and since the upkeep and operating cost of the oil engine unit would be higher than for a motor driven unit, we have deemed it unnecessary at this time to investigate this type of a prime mover.

When the boilers are so cut down in allowable working pressure as to make the use of the auxiliary steam fire pump no longer available, we believe an oil engine unit should be carefully considered.

SECTION VII.

Comparison Between Present Costs and Cost of Purchased Energy.

Another question asked is whether or not you can operate on purchased energy for light, power and pumping purposes, more economically than you do now with generated energy, and what would be the saving, or would it be better to buy energy for your daylight power load, and yourselves pump and supply electrical energy at night?

The conditions for the purchase of all electrical energy would be either the holding of your electrical

plant in reserve, or dismantling it to sell off the machinery, the latter being assumed in our estimates.

We understand that the insurance underwriters require that you have available, two sources of power supply to operate pump for fire purposes. This would be met by a source of electrical supply with a motor driven pump, the boilers and fire pump being held in reserve to be started up in case of a breakdown on the other supply. We believe the Underwriters letter read in our presence, required that the steam plant be capable of starting up within 12 hours of shut down of other supply. This would not require you to keep steam in your boilers, but would require that everything be kept in condition, and that an engineer would be available. Your present fire pump has a capacity of 700 gallons per minute (the big pump 870 gallons per minute) and we should probably advise a motor driven triplex pump of about 400 gallons per minute capacity. Such a pump would be a 10 inch x 10 inch (approx.) requiring under your conditions a 25 h. p. motor. To pump (say) 36,000,000 gallons per year at 400 gallons per minute would require an operation of 1500 hours or 37,500 horse power hours equivalent to 28,125 kw. hours. To figure the cost we would allow about 30,000 kw. hours at meters (the extra for station losses and this at 2 1-2 cents would cost

about	$750.00
Repairs, oil, waste, etc..........................	250.00
	$1,000.00

This cost is not complete, since the increased fixed charges must be added.

Pump fully fitted	$1,200.00
Motor and belt	600.00
Foundation	200.00
Piping	300.00
	$2,300.00

You could probably obtain for the big pump, condenser, etc. 50.00

So the net cost would be. $2,250.00

Note: It may be possible to arrange with the party supplying electrical energy to furnish and install a pumping outfit, but if such is the case, we advise that it be of approved design and construction.

The fixed charges on this would be 8 per cent for interest and depreciation or. 180.00

This gives a total cost of. $1,180.00

Your corresponding present cost is as elsewhere figured $1,138.00

No labor is included in either of the above, and we see no reason why it would be changed from the amount allowed of $440 which gives:

Total cost Water Works as at present. $1,578.00

Total cost Water Works electric driven. 1,620.00

A difference of $42 which of course is unfavorable to a change, and further is too small to consider.

Should, however, the electrical plant be done away with, thus requiring less labor attention, we believe 4-5 of a man's time would be charged to the Water Works or 4-5 or $940 equals $752 which is $312 more for labor than is included in the above figures, making the total, under conditions of the electrical load being purchased, $1932.

If the pumping is done by steam, and electrical energy purchased for all the electrical load, that is none generated by town plant, the cost of pumping would be high.

The basis used for the estimate of such service, is that of the May 10th test, it being considered a typical day.

Coal burned 1064 pounds. Add for building up fire 300 pounds and for banking 300 pounds. Total 1664 pounds.

Gallons pumped 89,700.

Coal per 1,000 gallons equals 18.55 pounds.

Coal for year 36,014.000 gallons x 18.55 pounds equals 668,060 pounds.

Say 75 per cent coal or 501,055 @ $4.93 per ton equals	$1,103.00
25 per cent screenings or 167,015 @ $2.82 per ton equals	210.00
	$1,313.00
Labor 1 man 4-5 of $490	564.00
Repairs, etc. as now	300.00
Oil and waste as now	45.00
	$2,222.00

This is $290 more than the cost of an electrical driven water works pump.

We would then answer part of the question as to whether it would be cheaper to buy electrical energy at 2 1-2 cents, than to operate your steam driven pump, as follows for the various conditions:—

(a) Electric plant steam driven as at present. Water works steam driven or electrically driven. The cost is practically the same.

(b) Electric plant purchasing current. Water works electrically driven. This would cost the Water Works $354 more than at present. Water Works steam driven. This would cost the Water Works $290 more than an electric driven water works pump.

To these figures for steam driven Water Works cost under this condition of purchased electric energy for electric plant, there would have to be charged the entire maintenance, insurance and interest of the boilers

and piping, a large part of the building maintenance, insurance and interest, as a partial offset, there being the rent charged the Electric Dept. for space, as at present. Such charges are not considered here, however, as they are matters due to fire risk chiefly, and have to be paid by one department or the other in any case.

We next consider whether the Electric Dept. would be more cheaply operated on purchased rather than upon steam generated energy.

Our figures show a station unit cost of 3.26 cents per kw. hour generated at the station, and a total cost of $6811 divided into these items:—

Labor, $1760; oil and waste, $140; fuel, $4511.
Repairs, insurance and supplies $400.

With purchased current you would save all the above labor, and would be charged by the Water Works 1-5 of one man or..........	$ 188.00
No oil, waste or fuel would be required.........	0
Repairs, insurance and supplies would be reduced to	200.00
Fuel would not be required	0
Bills for purchased energy 208,587 kw. hours @ 2 1-2c	5,215.00
Total	$5,603.00

Changes in the station apparatus would undoubtedly be required for which we allow $1,000.

The engines and generators would be sold to bring about 1-3 of their first cost ($7,800) $2,600.

This decreases the investment by $1,600.

The fixed charges are then decreased 8 per cent (interest and dprs.) on $1,600.......	$ 128.00
Giving a total yearly cost of..................	$5,475.00
This figure shows a decreased yearly cost of....	1,336.00

If the plant is run 24 hours there will be an additional bill for electrical energy of 16,524 kw. hours @ 2.5 cents.................... 413.00

Which would make a total cost for 24 hour service of 5,888.00

As against an estimated cost for 24 hour service steam driven of $6,811 plus 1607......... 8,418.00

The total saving under these conditions being.. 2,530.00

Considering both departments together we have the following financial savings:

Present hours of service, present cost $8,389.00.

	Costs New	Saved
Electric Dept. operated on purchased current, $5,475. Water Works steam driven, $2,222..	$7,697.00	$ 692.00
Electric Dept. operated on purchased current, $5,475. Water Works electrically driven, $1,932	7,407	982.00
24 hours of service estimated steam driven cost $9,996.		
Electric Dept. operated on purchased current, $5,888. Water Works steam driven, $2.222..	8,110.00	1,886.00
Electric Dept. operated on purchased current, $5,888. Water Works electrically driven, $1,932	7,820	2,176.00

These figures show that in any one of the operating conditions under consideration, the town would save money by purchase of electrical energy at 2 1-2 cents, over its present operating costs, for service of less than 24 hours per day, or over the estimated operating costs steam driven for 24 hour service.

SECTION VIII.

Remarks on Distributing System.

We did not go over this system in any way, so make

only a few remarks regarding the transformers on the lines.

Street Lighting.

The street lighting consumes about 20 kw. per hour, and we believe this could be reduced considerably by the installation of series Tungsten lamps. You have 18 kw. of transformers on this line.

The 1912 Gas and Elec. Light Com'n. report states that you have 11-40w and 310-60w lamps (p 262) and also 16 c. p. 60w lamps and 30 c. p. 40w lamps (p 265) from which we judge that the 310-60w lamps are 16 c. p. carbon ones taking 18.6 kw. If you had 310-25 c. p. 40w lamps they would take only 12.4 kw. or 2-3 the present consumption, and give more light. Your street lights are all constant potential lamps while the best practice now is to do the street lighting with constant current series tungsten lamps, using a constant current transformer at the power station.

While in 1912 according to the Gas and Elec. Light Com'n. method of figuring the cost of the street lamps you have figures $1.97 and $1.31 per year (p 265) this cost should not mislead you as to the cost of the service, since the method of figuring means nothing as to the real cost of service. You will note that the credit balance from commercial service is credited the street lighting costs. This method would, if the commercial profits were large enough, work out so that the expense of the street lighting was nil or even a negative cost, that is a profit, and of course such a condition is ridiculous.

Assuming 20 kw. per hour for 2,054 hours we have 41,080 kw. hours consumption, and using 12 pounds of

coal per kw. hour, this means 492,960 pounds of coal, or 220 tons of coal @ $5. equals $1,100.

$1,100 divided by 321 (no. of lamps) equals $3.43 per lamp. This charge is for coal alone, labor, interest, depreciation, repairs, renewals, etc. charges all having to be added.

Commercial Lighting.

We are informed that you have for commercial (stores) and domestic (house) lighting, the following transformers on the line:—

No.	1	5	4	3	2	7	2	2	Total 26
Size kw.	½	1	2	3	4	5	7½	10	Total 100½

Also one 10 kw. transformer for single phase power on the lighting circuit.

The maximum load on this circuit during test was for one hour 17 kw., and from the station records in part of March and April of this year 23 kw. The 1912 Town Report shows you have 100 services or 1 kw. per service. The 1912 Gas and Electric Light Commission report gives the following installed lamps 1513-50w units and 109-40w units, or 80 kw. capacity. This means you have a greater kw. capacity in transformers than you have lamps installed, which is an uneconomical operating condition, since the transformers are never loaded, and there is a greater loss all the time the primary side is alive than there need be.

Power.

We are informed that you have the following power transformers:—

No.	4	4	2	2	Total 12
Size kw.	4	20	10	5	Total 126 kw.

Also one 10 kw. transformer for single phase power on the lighting circuit.

The maximum load on the power during the test was

for one hour 46 kw. and from the station records in part of March and April of this year 61 kw. The 1912 Town Report shows you have 8 power services or 16 kw. of transformers per service. The 1912 Gas and Electric Light Commission report fails to show the power connected load, so we can draw no conclusions from this.

General.

We have not much doubt but that a revision of the distributing system could be made to meet present load requirements, which would reduce standby losses outside the station.

Our experience has been that in nearly all systems which are the outgrowth of needs as they arose from time to time, and where no general revision has been made for some years, almost always show opportunities for improvements, so we should naturally expect such to be the conditions in Merrimac.

Since, however, the condition causing expensive operation is in the amount of load for the size units installed, the saving to be expected from any improvement in distributing system, would be small.

We advise in any plan of operation, that the condition of the distributing system be investigated carefully, and if justifiable, that changes be made.

SECTION IX.

Estimate of Possible Economies.

Up to this section of the report we have considered only the cost of operating the plant, both Water Works and Electric, on the basis of what you are now doing, as shown from our test and your records.

We have drawn comparisons between present costs and costs under procedures suggested by you to accomplish certain results, such estimates being all based on the costs

found to prevail under present conditions and management.

In this section we propose to indicate what we believe the costs should be under proper working conditions, first pointing out reasons as we see them, for the present high costs.

Boilers.

The boilers have have had hard treatment and retubing has been required on each one, and patching on one. The items of new checks, arches and fire brick seem to occur rather frequently in the Town Reports, namely 1906, 1907, 1909, 1910, 1911 and in 1908 new mouth pieces were required, and in 1910 new grates. This indicates that the fires are carried too far forward on the grate. In 1911 when retubing and patching was done, the repair expense amounted to $1,087.11. We cannot but feel that if proper solvent had been used in the boilers or water changed, either method requiring but little attention and expense, considerable of this expense would have been saved. The boilers are (Oct. 1904 to Oct. 1914) 10 years old at this time.

We understand that graphite is used as a solvent in the boilers to some extent. The U. S. Navy Dept. has determined by tests that graphite hastens rather than retards corrosion.

Judging from the fires carried under the boilers on the test, we believe that a thicker fire would cause a saving in coal, as it seemed to us the fire was so thin as to cause the coal to burn too freely.

The plant should be so run as not to require more than one boiler at a time, and to load this boiler as nearly to its full capacity uniformly as possible.

Engines and Generators.

The engines we are told, have required considerable work on them this year, in the way of reboring a

cylinder, grinding valves, etc. and the small unit was pounding at the time of the test. The repair items for steam and electric plant, have amounted to nearly $1,-000 since the start, averaging $120 per year.

We cannot think these charges heavy or unusual, but think the units should be in better shape than they are.

We have elsewhere discussed the question of running the small engine on the day load, advising its use at such times.

Labor.

We do not believe you could run more economically on labor, as you have a minimum number of men employed, and the wages are not excessive for the hours put in.

Oil and Waste.

This item seems high to us, amounting to $45 for the Water Works and $140 for the Electric plant. We should think $25 enough for the former, and not over $50 for the latter. There should be a saving here of at least $100 we believe, if the oil was properly filtered, re-used and not wasted.

Switchboard

We think it would be well to have the switchboard instruments calibrated and corrected.

In our preliminary report we advised the removal of the voltage boosters, if no longer needed or of any use. No one was able to explain their use to us. They are a type which are no longer installed, and we doubt whether they are manufactured.

Feed Water Pump.

This pump was in shocking condition, as shown by

its breakdown at the time of the test. We were told that the parts for its repair had been ordered, but from its condition feel that they should have been installed some months ago. When a feed pump gets into such poor condition that a bar has to be kept near it to pry and pound it into operation, poor or no attempt at proper upkeep is evident.

There should be duplicate feed pumps, or at least a supplementary injector. Your breakdown feed water supply was from the town service lines, **through the feed pump**, making its use impossible if pump was broken and under repair.

Water Works Pump and Auxiliaries.

This pumping outfit is operated about 4 hours each day, to supply the daily draft from the reservoir, and during this time is operated only at half speed. Such operation means poor economy. It was stated that the pump could not obtain water from the wells in sufficient quantities to be operated at full speed, that is at full capacity. This shows the wells need cleaning out.

The steam cylinders are steam jacketted, but since something is broken the jackets are not used. This means decreased economy again. The auxiliary pumps are in very poor condition, and here again a bar is kept handy to pry and pound the pumps into operation.

It may be possible to repair these pumps so they will give satisfactory operation, but from their actions they seem fit for the junk heap.

The condenser we could not examine, so say nothing regarding its condition.

The big pump is of a type which it was customary to install some years ago for such a plant, but this type is no longer used, and we are told by a pump manufacturer that if you figured on getting the pump taken out of the plant, and obtaining $75 from the purchaser,

he would consider that you were expecting too much.

Street Lighting.

See section "Remarks on Distributing System."

The Plant.

The plant has been very inadequately kept up, and in many ways the upkeep has been nil.

Since the town cannot afford to employ a first class superintendent for so small a plant, it would seem that the next best thing would be to employ some outside party with the requisite knowledge and experience, to put in part of his time each week as may be necessary, to see that things are properly looked after, and for the Town Committees to back their appointee in his efforts. It will be said that such a man would cost more than you now pay, and we know such would be so, but believe that the economies and savings which such a man would make after he had had time to put the plant in proper condition, would more than offset the cost of his services.

Coal.

The largest item of expense in the plant operation is coal, and any economy of a considerable amount would be made here.

Under the following conditions we should expect the savings shown by the figures here given.

Start plant in a. m. as now, operate power load to 5 p. m. and not longer, unless there was more demand for same than at present, remove the 10 kw. transformer used for power, from the lighting circuit, so as to save no-load losses when not in use, and change the 1 phase motor to 2 ph. as required by power circuit or balance the circuit, do pumping after the power load was off in the periods 5 p. m. to 7:30 p. m. and 10:30 p. m. to 1 a. m. (these periods would vary with the seasons and loads of course.)

This would call for 1 boiler at a time, and the use of the small engine, except at times when load was much heavier than we found it. If 24 hour service was to be given, we advise the installation of a small unit of some type, to carry the load from say 10 p. m. until the morning start, such a unit to be installed after the present plant had been run long enough to determine the load requirements.

Under above conditions:

We estimate average pounds coal per kw. 8.

Average evaporation per pounds of coal 9.

Water Works

6682 pounds steam per day x 365 days divided by 9 pounds evaporation equals 270,992 pounds of coal per year.

Electric Dept.

208,600 kw. hours x 8 pounds coal equals 1,668,800

1,939,792

pounds coal, say 1,940,000.

1,940,000 divided by 2240 equals 867 tons @ $4.93 equals $4,274, say $4,300.00

For 1913 the cost of coal and screenings with same number of kw. hours output was:

Coal 2,027,184 lbs. equals 905 ts. @ $4.93 equals $4,460.00

Screenings 667,844 lbs. equals 298 ts. @ $2.82 equals 840.00 5,300.00

Showing a saving of $1,000.00

Unit cost of 1 kw. hour	Cents
8 lbs. of coal per kw. hour means..................	1.76
Unit charge for labor previously found............	.843
Unit charge for oil and waste reduced by economy. .	.03
Unit charge for repairs, insurance, etc.............	.19
Total unit charge	2.823

In the above figures for Water Works, no economy of steam consumption has been figured over present conditions for the Water Works pumps, and while we believe some economy could be made here, we feel certain that the steam pump auxiliaries are very uneconomical, in their present condition. They now consume nearly 49 per cent as much steam as is used by the big pump alone, whereas it should be not over 15 per cent. This would mean a saving in coal on the above basis of 1513 pounds of steam x 365 days divided by 9 evap. equals 61,361 pounds coal or 27.4 tons @ $4.93 equals $135 about.

This figure is over 17 per cent of the present coal cost for the Water Works as elsewhere figured. Combining these savings we get a total saving in cost of about $1,135 or over 13 per cent of the present total cost.

Such a saving is of course well worth while.

Referring to the costs of operation Sect. VII your present total cost as there used is..............$8,389.00
Possible savings as here outlined............. 1,135.00

Cost with economies effected $7,254.00

For the present hours of service you would then not save money by purchase of 2 1-2 cent energy, such cost being under various conditions as follows:

		Loss
Electric Dept. on purchased energy...	$5,475.00	
Water Works electrically driven......	1,932.00	
	$7,407.00	$153.00

Since the above saving would apply to the expense as estimated for 24 hour service, the increased hours of operation being still as uneconomical as before, we find the total cost would be:
24 hours of service

Previous estimated cost	$9,996.00	
Savings estimated	$1,135.00	
	$8,861.00	
		Savings
Elec. Dept. operated on purchased current, Water Works electrically driven	$7,820.00	$1,041.00

These figures show that if operation can be carried on for same hours as at present, but with greater efficiency, it would not pay to make the change, since the cost of purchased current operation would be higher with 2 1-2 cent energy.

On the other hand with 24 hour service, the saving with 2 1-2 cents energy is material, namely 1041, even with economies suggested in practice.

If you can obtain the price of 2 cents per kw. hour the cost would be for electricity.

Present hours of service. Present costs $7,254 with economies practiced.

Electric Dept. operated on purchased		Savings
current	$4,432.00	
Pump electrically driven	$1,782.00	
	$6,214.00	$1.040.00
24 hours of service estimated steam operating cost $8,861 economies practiced.		
Electric Dept. operated on purchased current	$4,514.00	
Pump electrically driven	1,782.00	
	$6,296.00	$2,565.00

These figures show with purchased energy at 2c, as against economical operation of steam plant, a saving of

$1,040. for present hours of use, instead of a loss as figured with 2 1-2c energy, and for 24 hour service, a saving of $2,565 as against a saving of $1,041 at the 2 1-2c energy rate.

SECTION X.

Data Regarding Purchased Energy.

For your information we give information as to the prices paid by certain municipalities in the state for electrical energy.

Of course the terms, hours of use, type of load, etc. all enter into the price at which energy can be sold, and on the various conditions controlling the price, no information is available.

Municipality	kw. hrs. Purchased 1912	Cts. per kw. hr.
Ashburnham	56,160	4.0
Groton	35,970	5.6
Hingham	342,264	3.87
Hull	124,395	P2.0
Norwood	1,136,000	2.33
Shrewsbury	87,770	5.0
Wakefield	148,849	P2.62
West Boylston	44,369	2.5
Belmont	307,704	3.67
Groveland	80,462	3.5
Holden	10,912	2.49
Millers Falls	60,970	3.2
Rowley	27,130	6.0
Templeton	82,851	3.44
Wellesley	521,140	2.78

P means purchase is only part of total output.

Regarding what other municipalities are doing in

connection with source of energy, we quote from an editorial in the Municipal Journal of Aug. 27, 1914:

"Of 35 Massachusetts municipal plants, 17 purchase energy, 15 use steam alone, 2 use steam and water and 1 uses fuel oil.

"The practice of purchasing current from large generating plants is increasing, and is undoubtedly wise economy in many cases, especially of small plants, or of those which have no water power.

"Any business man can readily appreciate that in many cases, to fail to do so (that is purchase) would be foolishly uneconomical.

"Aside from this argument (not here quoted) is the fact that in the same state, 22 private lighting companies purchase current from other companies. In addition 204 towns are served by 46 private companies, in most cases a single plant generating the current for all the places served by that company. No stronger argument is needed to prove the true economy of distributing the current from one plant for several municipalities. It would be foolish to premit local pride or other equally unimportant reasons to interfere with the exercise of such economy."

SECTION XI.

Sources for Purchase of Outside Energy.

We understand that you have been approached by both the Haverhill Electric Co., and the Amesbury Electric Light Co., regarding the purchase of energy from them.

The former company has not to our knowledge, named any figure at which they will furnish, but we see no reason on general principles why they would not meet the Amesbury figure.

The latter company have given us a copy of a letter to Mr. Willis H. Scott, dated 26 March, 1914, which outlines their proposition as follows, with remarks by us.

General. (a) Term for at least three years.

We are informed by a Boston representative, that they would supply for 1 year on trial, and then make a 10 year contract. (See later statement.)

(b) The total yearly consumption will be 200,000 kw. hr., of which the day load is greater than the night load.

We believe this will be the consumption, but should be adverse to the town binding itself to this consumption, and especially so if pumping was not done electrically.

(c) That facilities for setting of poles, running lines, etc. be given by the town.

(d) That in case of failure to supply by Amesbury, necessitating generation by the town, there will be a pro rata reduction from its bills. That for the shut down period of supply, the Amesbury Co. will pay the town 2 1-2c per kw. hour generated.

We do not approve of this payment of 2 1-2 cents in any case or term of contract, and should wish a larger amount, or the operation of your plant by the Amesbury Co., during the shut down period at their own expense. Of course in case of a one year trial, you would still have your plant, but if a ten year contract was entered into, you would not retain the apparatus, so some forfeiture clause would be required.

(e) First proposition; a minimum supply of 170,000 kw. hours at 2 1-2 cents with an increase in unit price not to exceed 3 1-2 cents in minimum falls below above total.

This seems reasonable, except that we should except the price to be more favorable than 2 1-2 cents under the long term contract.

Second proposition: A supply from 12 midnight or 1 a. m. to 4 p. m. the next afternoon, for not less than 100,-000 kw. hours annually at 2 1-2c per kw. hour.

This proposition is not attractive, since they take

all or nearly all the day power load, and leave you to operate the uneconomical load. We do not see that you are interested in this proposition.

Third proposition: Night supply from 6 p. m. to 7 a. m. on an estimated amount of 100,000 kw. hrs. at 3c per kw. hr.

You could not guarantee such an output, but if you wish 24-hour power and do not wish to operate the plant the additional time, we think some attractive proposition could be worked out of this proposition.

The letter states that the hours mentioned in the 2d and 3rd propositions, are approximate only, and are subject to change as mutually agreed upon.

The Boston representative, Mr. Parsons, stated that they would be willing for one year, with the understanding that a ten year contract would be later made, if the town decided to continue the purchase of current, to install a 25 h. p. motor driven pump unit complete, without cost to the town, furnishing energy at 2 1-2 cents per kw. hr. at your bus bars provided for this year, and in case of renewal they furnished all your electric and pumping power.

To our mind this seems a favorable offer for a one year contract, if you intend to continue operation on the present uneconomical basis, but the price would have to be reduced before you could afford to accept it if economies were to be practiced, and the details would have to be satisfactory in any case.

If the town decides to consider the purchase of electric current on any basis whatever, it would be advisable to submit the probable requirements to both the Amesbury and Haverhill companies, and let them make their propositions along the same lines for comparison, and also make any individual propositions they might desire.

SECTION XII.

Conclusions.

A summary of our observations and our deductions are made below, and then conclusions are drawn from them.

The station plant as a whole is in poor shape, and has been allowed to run down in condition so that economical operation even under the load conditions is not obtained.

The pumping is not done at the most advantageous time from the standpoint of station economy, since the pump is operated at maximum electrical load period, requiring the use of an additional boiler which would otherwise remain without fire, and the consequent coal consumption would be saved.

The feed pump and large pump auxiliaries were in shameful condition, and while the former has we are told, been put in working condition, the latter act as though they belonged in the junk heap.

The big pump is run at 1-2 speed, because at full speed (we are told) the water supply fails. This is an uneconomical operating condition. Further the steam cylinders are not operated with steam in the jackets, as was intended by the pump construction, to improve the economy.

Judging from the above statement regarding lack of water supply, the wells need cleaning out.

We have not examined the conditions of the electrical distributing system, so can only say as elsewhere outlined, that we believe there is chance for economy here, although not of considerable amount.

With economies in the station which we believe attainable, the cost of operation would be less than it would be with purchase of current at figure of 2 1-2 cents per kw. hour, but more than it would be for 2 cent rate.

for present hours of operation. With a 2 1-2 cent rate and 24 hour operation, there would be a saving made, but with a 2 cent rate, this saving becomes very material.

We understand that there is a strong desire in the town for 24 hour service.

We also understand that some of the committee believe the plant should be run on test for a considerable period, and conclusions drawn from data of such a run.

Should the town adopt this plan, we suggest that the plant be put under the charge of an outside engineer who would have authority to control the help, make reasonable repairs, etc. and put the plant in good operating condition, and that the test run be begun only after the desired repairs, etc. were made. Such a run would show what the plant was capable of doing if properly looked after, and results would be free from any partisanship which may exist in the town.

We therefore conclude:

1. That economies approximating $1,100 yearly could be advantageously practiced for present steam operating conditions.

2. That purchase of energy for the electrical load requirements and for Water Works pumping, could be advantageously made (comparison being made with cost of economical steam operation.)

(a) For 24 hour service at a rate of 2 1-2 cents the saving being about $1,000.

(b) For 24 hour service at a rate of 2 cents the saving being about $2,500.

(c) For present hours of service at a rate of 2 cents the saving being about $1,000.

No saving would be made for present hours of service at a 2 1-2 cent rate, there being a greater cost.

3. That under above conditions the town would be justified in making a ten year contract under reasonable

conditions of payment, hours of use, regulation, lamp supply, etc. and possible purchase of present electrical units, with satisfactory parties.

4. That to take advantage of the suggested purchase, it would be advisable to

(a) Remove present large Water Works pump, auxiliaries, etc. installing a 400 gallon per minute motor driven pump.

(b) Remove present steam driven units, selling same when a fair offer was obtainable.

(c) Maintain present boilers and auxiliary fire pump in condition for emergency operation, as required by the Underwriters, namely so that pump could be started up in 12 hours. The substitution of electrically diven pump, and above plan of mainteance to be approved by Underwriters before any change is made.

5. That if the town is not ready to purchase electricity, that a test 6 months or a year be run under control of outside disinterested parties, and a decision made after results of such a run are known.

We believe, however, that even under such a run, the operating results will be greater than they would be with purchased energy at 2 cents or thereabouts, under partial 24 hour operation, and more so under 24 hour operation.

Before any contract is signed, you should have the supplying company's plant looked over, with a view to its reliability and capacity to handle your peak load.

From our general knowledge of what is going on elsewhere, we believe it would be wiser for the town to now act finally in favor of purchase of electricity, than to continue the present plant use, as we feel that such action will eventually come in one way or another, any action in this direction simply being delayed without compensating advantages.

REPORT SUBMITTED BY COMMITTEE.

A report of the town's committee to investigate the cost of running the Light and Water plant, as voted at the annual town meeting, March 2, 1914.

Voted:—That we, the legal voters of the Town of Merrimac, do hereby appoint a committee, consisting of the Electric Light and Water Board, the Chairman of the Selectmen, also all of the power takers of the electricity manufactured by the town, also of the ten largest house takers. This committee shall investigate the cost of running our plant all night, giving continuous service; also any and all matters pertaining to the plant and to the pumping of water, that seems advisable. This committee shall have full power, if it deems advisable, to employ a competent engineer to obtain any information they desire. This committee to report their findings at an adjourned meeting thirty days from date.

It is further voted that five property owners, not light takers, be added to the committee, and the following were chosen by the meeting: Homer R. Sargent, Edson C. Walker, Frank E. Bartlett, John K. Sargent, Chas. Emery Hoyt.

The committee:—James W. Bailey, of the selectmen, Willis H. Scott, Warren H. Bailey and George A. Titcomb of the Light and Water Board, The J. B. Judkins Co., The George W. Murphy Co., Jonah and George, Merrimac Plating Works, Joseph P. Laskey, Clifton B. Heath, Sawyer and Titcomb, power takers; Sidney F. Greenwood, Frank Hargraves, Harry W. Hale, H. A.

Jackson, Judson S. Swett, Fred B. Judkins, A. O. Kinsman, Robert O. Patten, William C. Russell and Fred E. Sweetsir, largest house users; Edson C. Walker, Homer Sargent, John K. Sargent, Frank E. Bartlett and Charles Emery Hoyt, property owners, not light takers.

Of the committee, several of the power takers not being legal voters, and others who did not care to give their time to the matter, twenty-one was the largest number present at any one meeting and fifteen has been an average attendance.

The first meeting of the committee was held March 6th. Frank E. Bartlett was chosen chairman, and H. A. Jackson secretary. A sub-committee of five was chosen to investigate the cost of running the plant in the past and to make as complete a report as possible. This committee consisted of Willis H. Scott, H .A. Jackson, Jos. P. Laskey, Judson S. Jewett and Wm. C. Russell. A sub-committee of three was chosen to confer with the Haverhill Electric Light Co. and the Amesbury Electric Light Co. on cost of purchased current. This committee consisted of Willis H. Scott, Fred E. Sweetsir and Harry W. Hale. Warren H. Bailey, Joseph P. Laskey and A. Burley Sawyer were chosen as a committee as to whether it would be advisable to raise the water rates.

It was early agreed, by the committee, that the only way to get at the cost of running our plant to the satisfaction of the voters of the town, would be to employ engineers familiar with such business. It was voted that the sub-committee on plant be authorized to employ consulting engineers, and from three firms recommended, the services of Richardson and Hale, of Boston were secured, and that each voter should receive their report in full.

Owing to the technality of a report of this kind, it is not easy to follow it in all its detail; but it establishes beyond controversy, certain facts, the principal one of

which is, that we are not operating our plant upon business principles and call your especial attention to the sections of the engineers' report.

Pages 16-17—That the total output of the plant is far below its economical capacity. It is shown that the small generating unit could satisfactorily take care of the present day load, had the plant a voltage regulator, doing away with the running of the large unit so much of the time. Page 17 shows this loss to be $200.00 per year.

Pages 23-30 inclusive, shows the present cost of operation yearly, at the station, also the division cost of water and electricity, this per cent will vary as the amount of water pumped to the electricity generated, varies from month to month.

Page 33 sect. 4—The plant runs almost exactly ⅔ of the time approximating 6004 hours.

Page 34 shows that to run the plant continuously for the twenty-four yours would cost $1,600.00 more, than for the hours now operated.

Page 35 sect. 5—Unbusiness-like method of pumping the water by day, for years, when it could have been done much more economically by night, at the hours of the light load.

Page 52—Purchased current at two cents per k. w. with economies practised, as recommended by Richardson and Hale, shows a saving of $1040.00 for the hours the plant is now operated, and for the twenty-four hours continuous service a saving of $2,565.00; but we are told by the superintendent that these economies can not be put in practice, then so much more the better business proposition for the town to purchase current at two cents per k. w. a saving for the present hours of service of $2,175.00 and $3,700.00 for the twenty-four continuous service—$10.00 per day.

The sub-committee having conferred with the Ames-

bury Electric Light Co.. also the Haverhill Electric Light Co. and having received from the former, a bid of two cents flat per k. w. for current furnished at our station meter, therefore, we, the signers of this report feel justified in recommending that it is a matter of great economy for the town to purchase current at this price whether the plant runs with present hours of service, or gives continuous service for the twenty-four hours of each day, and as suggested by the consulting engineers.

In suming up your committee's work the matter was divided into four articles and the committee voted upon them in this proportion:—

Article 1—That it is the sentiment of the committee, that the town should have continuous service of electricity either by running the plant all of the time or by the purchase of current. 11 voted Yes, 4 voting No or not voting.

Article 2—That it is for the best interests of the town that the superintendent of the plant be not a member of the Light and Water Commission, 15 voting Yes, unanimous.

Article 3—That we recommend that the town should receive continuous service of electricity by buying all of its current for light and for the pumping of water, at a price of two cents per k. w. provided a suitable contract with the approval of the selectmen and town counsel as per offer of the Amesbury Electric Light Co. and as suggested by the consulting engineers. 10 voting Yes, 4 voting No or not voting.

Article 4—Should the town reject the proposition of purchasing current, shall the plant furnish the same by running all of the time? Nine voted No, 5 not voting or voting Yes.

Your committee also recommended that the plant should not be shut down during the noon hour, but continue to furnish current. Also that the consulting en-

gineers, Richardson and Hale should be present at the town meeting to be called to act upon this matter. and defend their report, at an expense not exceeding $50.00

Respectfully submitted,

H. A. JACKSON,
F. H. HARGRAVES,
JOS. P. LASKEY,
HARRY W. HALE,
WM. C. RUSSELL,
DR. F. E. SWEETSIR,
JUDSON S. JEWETT,
Committee.

The special committee on water rates recommended that there be no change in rates. Approved by the full committee and ordered to be printed in this report.

RICHARDSON & HALE
CONSULTING ENGINEERS
83 WATER STREET
BOSTON, MASS.

Table I

Merrimac Test May 7th 1914

Electrical Data (15 min. readings only)

Time	Voltage Primary	Voltage Second'y	Amperes Large Gen. L.	Amperes Large Gen. R.	Amperes Small Gen. L.	Amperes Small Gen. R.	Power Meter Reading	Power Meter Diff. Kw.hrs	St. Lt. Meter Reading	St. Lt. Meter Diff. Kw.hrs	Comm'l Meter Reading	Comm'l Meter Diff. Kw.hrs	Total Diffs Kwhrs.		Power Factor
6.45	2300	113.0	1	3			102445		221911		260143				
7	2275	111.0	2	5.5											
15	–	112.6	10.5	12.8											
30	2210	107.2	14.0	15.2			60	15		–	46	3	18		69.2
45	2220	107.6	13.0	15.0			70	10		–	47	1	11		
8	2275	112.0	13.5	15.8			80	10		–	48	1	11		
15	2275	111.2	13.2	15.6			90	10		–	49	1	11	44	67.0
30	2270	110.0	13.4	16.2			500	10		–	50	1	11		
45	2260	110.5	13.3	16.3			12	12		–	52	2	14	52	
9	–	–	14.0	16.8			24	12		–	53	1	13		
15	2230	108.5	14.6	17.5			34	10		–	55	2	12		70.5
30	2275	111.5	14.5	17.8			45	11		–	57	2	13		
45	2275	111.0	13.8	17.7			56	11		–	59	2	13	49	
10	2275	111.0	14.3	17.8			66	10		–	62	3	13		
15	2260	110.0	14.3	17.6			76	10		–	63	1	11		
30	2260	110.5	13.9	17.5			86	10		–	65	2	12		
45	2260	110.4	14.3	17.9			97	11		–	67	2	13		
11	2255	110.0	14.0	17.5			608	11		–	69	2	13	63	71.8
15	2260	110.2	13.5	16.4			20	12		–	71	2	14		
30	2250	110.0	14.6	17.4			31	11		–	73	2	13		
45	2250	110.0	13.8	16.8			41	10		–	74	1	11		
12	–	–	11.6	14.8			51	10		–	76	2	12		
55	2300	114	1	3.4			51	0		–	76	0	–		
1	2150	107	9	11.4			–	–		–	–	–	–		
15	2250	110	14.0	16.5			61	10		–	78	2	12		
30	2249	109	13.9	16.3			71	10		–	79	1	11	48	
45	2260	112	14.9	18.1			81	10		–	81	2	12		71.2
2	2260	111	14.2	17.9			92	11		–	83	2	13		
15	2250	111	13.0	16.0			704	12		–	85	2	14		
30	2250	111	14.0	18.0			15	11		–	86	1	13	55	
45	2250	110	13.5	17.5			27	12		–	88	2	14		
3	–	–	14.4	17.8			38	11		–	91	3	14		
15	2240	110	14.0	17.0			48	10		–	93	2	12		
30	2245	110	13.8	16.8			58	10		–	94	1	11	46	
45	–	109	16.2	18.0			68	10		–	96	2	12		
4	2230	109.5	16.2	17.5			78	10		–	97	1	11		
15	2240	110	16.0	17.1			91	13		–	98	1	14		
30	2240	110	13.9	16.6			801	10		–	200	2	12	52	
45	2240	110	14.0	17.0			14	13		–	02	2	15.0		
5	2260	113	10.5	13.6			24	10		–	03	1	11.0		
15	2320	115	3.5	8.0			26	2		–	04.5	1.5	3.5		
30	2180	105	2.9	6.4			28	2		–	05.5	1	3.0	12	
45	2210	109	3.0	6.0			30	2		–	06	0.5	2.5		
6	2200	106			6.0	2.5	32	2		–	07	1	3.0		
15	2220	108			6.0	2.5	35	3		–	08	1	4.0		
30	2250	110			6.5	3.0	36	1		–	09.5	1.5	2.5	14	70.4
45	2210	108			6.5	2.5	36	2		–	11	1.5	3.5		
7	2200	106	2.5	7.0			40	2		–	13	2	4.0		
15	–	–			–	–	–	–	–	–	–	–	–		
30	–	–			8.5	2.5	41	1	221911	–	19.6	3.6	4.6		
45	–	–			10.0	10.0	45	3	16	5	23	3.4	11.4	44.4	
8	2280	111			10.1	10.0	46	1	21	5	28	5.	11.0		95.0
15	2280	111			10.3	10.0	48	2	26	5	32	4	11.0		
30	2275	110			10.0	10.0	50	2	31	5	36	4	11.0		
45	2250	111			10.0	9.6	50	0	35.5	4.5	40	4	8.5		
9	2250	110			9.8	9.0	51	1	41	5.5	44	4	10.5		
15	2300	114			8.8	7.0	52	1	45.5	4.5	47	3	8.5	38	
30	2270	112			8.5	6.9	54	2	51	5.5	50	3	10.5		
45	2300	112			8.5	6.8	55	1	55.5	4.5	52.5	2.5	8.0		
10	2290	113			8.0	6.0	Power off 9.51	–	61	5.5	55	2.5	8.0		
15	2360	113			8.0	5.5		–	65	4	57	2	6.0		
30	2290	113			7.5	5.0		–	70.5	5.5	59.5	2.5	8.0	25	86.7
45	2280	111			7.7	5.0		–	75	4.5	61	1.5	6.0		
11	2270	111			7.7	5.0		–	80	5	62	1	6.0		
15	2290	112			8.0	5.0		–	85	5	64	2	7.0		
30	2290	112			8.0	5.0		–	90	5	65	1	6.0	25	
45	2250	110			7.5	5.0		–	95	5	66	1	6.0		
12	2250	110			7.5	5.0		–	000	5	68	2	7.0		
15	2260	110			8.0	5.0		–	05	5	69	1	6.0		
30	2260	110			7.5	5.0		–	10	5	70	1	6.0	25	
45	2260	110			7.8	5.0		–	15	5	71	1	6.0		
1	2260	110			7.8	5.0		–	20	5	out 72	1	6.0		

Sharp peak max. amps. A.M. 17.5, 20.0 2240v Large Gen.
P.M. 17.0, 20.0 (1/2 min) " "
10.3, 10.1 2280v Small "

RICHARDSON & HALE
CONSULTING ENGINEERS
83 WATER STREET
BOSTON, MASS.

Table II
Merrimac Test May 7th 1914
Boiler Test Data

Time	Boiler Gauges #1 Left	Boiler Gauges #2 Right	Feed Water Temp. #1 °F	Feed Water Temp. #2 °F	Coal lbs Weighed in Net lbs	Coal lbs Total lbs	Water #1 Bbl 445.5 lbs	Water #2 Bbl 448.5 lbs	Water Total lbs	Remarks
5.45					259					#1 Boiler Gauge 5" water; #2 " " 3" "
6.15							1	1	894.0	
6.30					332	591		1	448.5	
45	80	77							Temp. 56°	#2 being used; #1 building up
7	82	80			346	937			448.5	Large Engine started
15	77	76		190-202						
25				192						
30	90	87		194			1	1	894.0	
43				190						
45	83	82		183	320	1257	2	1	1339.5	
8	86	84					1	1	894.0	
5			187							
10			192							
15	86	84	188	188			1	2	1342.5	
30	86	84	201	201	330	1587	1	2	1342.5	
40			195	195						
45	90	87	192	192	315	1902	2	2	1788.0	
9	84	82	196	196			1	2	1342.5	
10			190	190			1	1	894.0	
15	87	84								
25			187	187						Outside Temp 66° F
30	87	85	183	183			2	1	1339.5	
40	84	87	195	195						Large Eng. 298 rpm
45					330	2232	1	2	1342.5	
10	92	91						1	448.5	
15	87	84	195	195			2	1	1339.5	
30	89	87	194	194	319	2551	1	2	1342.5	4/10" + Draft Gauge
45	92	89					1	1	894.0	#1 Boiler blew off at 11-2 for 2½ min
11	87	84			334	2885	2	2	1788.0	
15	90	88					2	1	1339.5	Flue Temp 625° F
25	87	85	195	195						
30							1	2	1342.5	Flue Temp 590° F with damper ½ open.
45	85	82	193	193	319	3204	2	1	1339.5	
50										
12	83	81	189	189				1	448.5	Sw pulled on line 12.3 PM
15							1	1	894.0	#1 Boiler water at String; #2 " " 2½" above; 100# coal (est) on hand; ½ bbl water
20	90	87							#1 Blew off 2½ min; Large Eng rpm 298; " Gen " 880	
45	86	84								
1	83 (sr Blew off)	81	No water fed since last temp reading except when sx blew							#1 Blew off 2m 50s
15	80	78			307	3511				Large Eng rpm 250; " Gen " 886
30	87	84	179	179			1	1	894.0	#1 Banked from 12 N
45	82	80		186			2	2	1798.0	
2	92	89					1	1	894.0	Outside Temp 74° F
8				190						
15	84	82			324	3835	1		445.5	Flue Temp 550° F damper ½ open. Draft 4/10 damper open
30	80	78		180				1	448.5	
45	88	87		178			3	1	1785.0	
55				182						
3							1		445.5	
15	90	88		189			1	2	1342.5	Large Eng rpm 250; " Gen " 882
30	87	87					3		1336.5	#1 Blew off 1m 50s
43	90	87								
45							1		445.5	
4	87	85			258	4093	1		445.5	
15	93	92		182			1	1	894.0	
30	89	87		194			2		891.0	
45	90	88		190			1	water gone	445.5	
5	84	83		180	159	4252	1	1	894.0	Water level in gauge glasses about same as at start
15	78	76					1	1	894.0	Small Eng fore 259 rpm; Large " shutdown 5.15; Small Eng 251 rpm
21	81	80								
30	88	87		189	157	4409	1	1	894.0	
45	84	83								
6	84	82					1	1	894.0	Small Eng 255 rpm; " Gen 715, 715, 711
15	81	82		190			1		445.5	Flue Temp 450° F damper wide open
25										
30					152	4561				
35	78	77					Temp 6.40 56° F			
45	76	74					1		445.5	
7	81	80					1	1	894.0	
15					150	4711	2	1	1339.5	
30	80	80		187	155	4866				
45	75	75		198	151	5023	2		891.0	Small Eng 254 252 rpm
8	77	77		200			2	1	1339.5	
15	81	81			160	5183		1	448.5	
21			195							
30	81	80								
36										
45	83	82			157	5340	1	1	894.0	Flue Temp 505° F
50				179						
9							2		891.0	
10	88	87		196						
15					151	5491		1	448.5	
20				188						
30							1		445.5	
38	87	87		191						Small Eng 255 rpm.
45	77	75		195	191	5682	2	1	1339.5	
10	78	77		195			1		445.5	#1 Fed 60# coal (part of measured amount)
15	80	79		195	132	5814		1	448.5	
30	77	77		193			1	1	894.0	
45										
11	76	75			185	5999	2	1	1339.5	
8				192						
15	77	77								Small Eng 253 rpm
30	77	77			133	6132	1	1	894.0	
45	84	83		183						
12	75	74			144	6276	1		445.5	
15	87	86		190			2		891.0	Water gone. Small Eng 255 rpm
22				192						
30	80	79			180	6956	1	1	894.0	#2 Boiler water ½" below String; #1 2" above String; Fire same as at start of load
45	82	81					1		445.5	
1					131 (banking)	6587				Engine shut down
15					104	6691				
30							1		445.5	
45	Condenser & pump trouble (air bound)							1	448.5	#2 Boiler water 2" below string
2							1		445.5	
30		81	Big pump started					1	448.5	#2 Boiler water 1½" below string; #1 ½" below string
45	90	89		179			1		445.5	
3 21	70	70								#2 Boiler water 2½" below String; #1 1¼" below string; Feed Pumps broke down

Notes

String on #2 Boiler is 1'-6" above C.L. of boiler.
" " #1 " 1'-7½" " " "

Ashes Weighed out 809 lbs.

Boiler main flue 36" dia Stack (est) 75' x 36" sq.

Large engine piston rod 2½" Small engine piston rod 1 31/32" dia.

RICHARDSON & HALE
CONSULTING ENGINEERS
85 WATER STREET
BOSTON, MASS.

Tables III and IV

Merrimac Test

Table III Data from Plant Test May 7 1914
Table IV Record by Months for 1914

Table III Data from Plant Test – May 7, 1914

Period (1)	Duration Hrs Min (2)	KWhours – Power (3)	KWhours – Comm'l (4)	KWhours – Street (5)	KWhours – Total (6)	Coal (lbs) (7)	Water Evap'd (lbs) (8)	Evap. per lb. coal (9)	Total lbs Water to Big Pump (10)	Total lbs Water to B P Auxiliaries (11)	Total lbs Water to Engines (12)	Estimated lbs coal to B Pump & Aux (13)	Estimated lbs of Coal to Engines (14)	Per KWhr for Elec Plant – Lbs Water (15)	Per KWhr for Elec Plant – lbs Coal (16)
5.45-7.45	2 0	25	4	0	29	937	2685	Warming up period on boilers, pump, engine etc.							
7.45-12 N	4 15	181	29	0	210	2067 2267	21802 22802	10.55 –	4495	3871	13436	1064	1003	64.0	4.78
"	4 15	181	29	0	210	(1) 2067	(2) 21802	10.55	4495	6682 (d) (2187)(e)	(c) (15120)	(f) (633)	(g) (1434)	(a) 72.0	(b) (6.82)
12 - 12.55	0 55	0	0	0	0	0	0		0	0	0	0	0	0	0
12 55 - 5	4 5	173	27	0	200	1089(3) 889	14405(4) 13405	13.24 –	0	0	14405	0	1089	72.0	5.45
5 - 7.30	2 30	17	13	0	30	618	5807	9.40	0	0	5807	0	618	193.6	20.6
7.30 - 10	2 30	14	36	50	100	971	6698	6.89	0	0	6698	0	971	67.0	9.71
10 - 1	3 0	0	17	59	76	774	6098 6698	7.88	0	0	6098	0	774	80.3	10.18
Total	19 15	410	126	109	645	6456	57495	8.91							

Notes

(1) Table amount decreased by 200 lbs due to coal on hand increased for banking.
(2) do by 1000 lbs due to height of water in glass on #1 boiler.
(3) (4) Increased by above decreases.
(a) (b) (c) (d) (e) (f) (g) items are derived by starting with an engine consumption per KW hr of 72.0 lbs since it seems reasonable to assume that the engine under practically the same load as in the PM would in the morning operate on the same lbs of water per KW hr.
To obtain division of water & coal for morning period as shown in brackets proceed as follows 72.0 (a) × 210 KWhr = 15120 (b) lbs water
21802 − 15120 = 6682 (d) lbs for pump and auxiliaries 6682 − 4495 = 2187 (e)
15120 (c) ÷ 10.55 evap = 1434 (g)
6682 (d) ÷ 10.55 " = 633 (f)

Table IV. Record by Months for 1913.

(1)	Pounds Coal (2)	Pounds Screenings (3)	Soft Coal equivalent to Screenings Ratio 6/7 (4)	Total Equivalent Soft Coal Pounds (5)	Hours of Engine Runs Hrs Min (6)	Hours of Pump Runs Hrs Min (7)	Hours of Street Light'g Hrs Min (8)	Power KWhrs by Customers Meters (9)	Power KWhrs by Sta Meters (10)	Street Lt KW hrs by Sta Meter (11)	Comm'l KWhrs by Sta Meter (12)	Total Station KWhrs (13)	Big Pump R.P.M Sta log. (14)	Big Pump Gallons Rpm x 25 (15)	Fire Pump RPM Sta. Log (16)	Fire Pump Gallons Rpm x 11.5 (17)	Total Gallons Pumped (18)
Jan	199200	76500	65500	264800	560-15	127-	218-55	9592	11120	3465	5735	20820	98445		14430		
Feb	217600	5400	4630	221930	485-55	111-	170-30	9250	10720	2480	4460	17660	96031				
March	222600	0	0	222600	525-45	125-15	171-15	8629	10000	2675	4090	16765	95528		27457		
Apr	180900	28200	24200	204100	488-50	104-	147-25	9378 + 16%	10890	2470	3345	16705	88620				
May	113200	107000	91700	204900	495-50	117-25	130-45	8488	9840	2195	3035	15070	103502				
June	166800	39600	33900	200700	475-45	178-35	120-30	8469	9830	2090	2665	14585	143443		15346		
July	156600	63600	54500	211100	498-05	162-10	130-30	Customers meters used for first 6 mos as Station meter was out of order	9720	2255	2835	14810	175701		48941		
Aug	115400	84000	72000	187400	497-10	209-55	144-25		9528	2590	2970	15088	161623		17539		
Sept	134200	75000	64300	198500	481-	130-55	171-20		9500	3105	3385	15990	101270		15222		
Oct	145500	90700	77700	223200	429-25	145-20	204-20		11350	3890	4720	19960	114687				
Nov	164700	54500	46700	211400	513-55	121-25	207-		10040	3980	5160	19180	100895				
Dec	210484	43344	37200	247684	552-	112-15	237-		11740	4390	5824	21954	96499				
Vertical Totals	2027184	667844	572430	2598314	6003-55	1645-15	2053-53		124276	36085	48224	208587	1376244	34416100	138935	1597753	36013853